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A new perspective on valuating marine climate regulation: The Israeli Mediterranean as a case study

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ABSTRACT

Marine climate regulation, the absorption and deposition of atmospheric carbon in the marine environment, is considered a valuable ecosystem service. Past valuations of this ecosystem service neglected to account for its temporal context, either by equating it with primary productivity, an underlying ecosystem process, or disregarded the temporal aspects related to its supply, thus leading to inaccurate valuations. This study presents a simplified spatiotemporal economic valuation methodology of the climate regulation ecosystem service, intended to address these shortcomings. The valuation was applied to the Israeli Exclusive Economic Zone (EEZ) by accounting for permanent and temporary carbon sequestration and the use of Social Cost of Carbon (SCC) values. Based on different carbon prices, the estimated value of climate regulation within the Israeli EEZ ranges between 265.1 and 1270.9 € km^{-2} $year^{-1}$, which is significantly lower compared with past methodologies applied in other areas.

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1. Introduction

During the past decade, the ecosystem services approach has gained increased popularity among ecologists and economists, linking between the physical state of ecosystems and socio-economic welfare (Daily et al., 2009; Jordan et al., 2010). However, compared with terrestrial ecosystems, applying the concept of ecosystem services and Ecosystem-Based Management (EBM) to marine ecosystems has been insufficiently addressed in the scientific literature (Böhnke-Henrichs et al., 2013), mainly due to difficulties in data gathering and the existence of considerable knowledge gaps. This is evident in the case of the eastern basin of the Mediterranean Sea, which is characterized as an ultraoligotrophic (nutrient-poor) environment (Herut et al., 2016; Siokou-Frangou et al., 2010), prone to high anthropogenic pressures and constant environmental changes (Coll et al., 2010; Kress et al., 2016; Lejeusne et al., 2010; UNEP/MAP, 2012), especially those related to climate change (Gertman et al., 2013; Ozer et al., 2016). Coupled with the limited information on its biogeochemical processes, ecosystem composition and functionality, compiling accurate and reliable valuations for the ecosystem services' flows of the Eastern Mediterranean basin is particularly challenging.

Among the various marine ecosystem services, climate regulation is considered a valuable asset to human welfare. In the context of the oceanic environment, climate regulation can be addressed as an ecosystem service rendered by marine ecosystems through the absorption and deposition of atmospheric carbon dioxide (CO_2) within deep oceanic layers by marine organisms, a process often referred to as the "biological pump" (Chisholm, 2000). After its formation by primary producers (such as algae or cyanobacteria) during photosynthesis, organic carbon is exported below the euphotic layer (depths corresponding to 0.1–1% of sunlight reaching the surface layer), where it is subjected to remineralization and solubilization at various depths (Raven and Falkowski, 1999). The fraction of organic carbon that remains within the ocean is dependent on various biogeochemical processes and its residence time within deep oceanic layers dictates the duration of temporary reduction of atmospheric CO_2 concentrations. The benefit derived from the prolonged sequestration of atmospheric CO_2 is the moderation of adverse climate change phenomena, such as extreme weather

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events, health risks or property damage, which are associated with high concentrations of climate-influencing substances in the atmosphere.

The aim of this paper is to assess the climate regulation ecosystem service through quantification of carbon sequestered by marine autotrophic organisms, and to estimate its economic value within Israel's Exclusive Economic Zone (EEZ) in the eastern Mediterranean Sea. The assessment is based on the fate of absorbed atmospheric CO_2 as an indicator of climate regulation and provides a quantitative estimation for the current and future supply of this ecosystem service.

1.1. Climate regulation assessment and valuation

Performing an assessment of ecosystem services requires a contextual linkage to human welfare. In the case of climate regulation, the duration of the removal of climate-changing substances from the atmosphere dictates its benefits to society. Delaying the re-release of these substances results in a temporary lower concentration of greenhouse gasses, thus helping to impede adverse climate change impacts. Past valuations of climate regulation, relying on the methodology set forth by Beaumont et al. (2008), equated climate regulation with primary productivity, i.e., fixed CO_2 by phytoplankton was considered as sequestered carbon and served as the primary metric for the economic valuation of this ecosystem service (Costanza et al., 2014; de Groot et al., 2012; Mangi et al., 2011; Murillas-Maza et al., 2011). In fact, the majority of the organic carbon generated through primary productivity is being remineralized during respiration by marine organisms and outgassed as CO_2 back to the atmosphere in a relatively short span of time. By disregarding the temporal context, i.e. equating primary productivity, an ecosystem process with climate regulation, an ecosystem service, overestimated values might occur. This is due to the high difference between the amount of organic carbon produced during primary production and the actual organic carbon that remains in the system afterwards.

Within the Israeli Mediterranean, few attempts have been made to evaluate marine climate regulation as an ecosystem service. Mangos et al. (2010) performed an assessment of various marine ecosystem services, including climate regulation, for Mediterranean countries. Their evaluation of this ecosystem service, which was based on the work of Huertas et al. (2009), relied on carbon sequestration originating in the solubilization of atmospheric CO_2, a process which is not related to ecosystems *per se*, and therefore does not fall into the common definition of ecosystem services (de Groot et al., 2010). A recent estimation of climate regulation in the Mediterranean, assessed both non-biological and biological components associated with this ecosystem service, modeling sea-air carbon flux. The assessment resulted in a value €2.7 million per year (100.4 € km^{-2} $year^{-1}$), for the Israeli EEZ (Melaku Canu et al., 2015). This study also revealed that, as a whole, the Israeli EEZ acts as a source rather than sink to atmospheric CO_2, but in the context of ecosystem services, the biological component within the oceanic carbon cycle acts as a sink, which hypothetical absence would cause higher levels of CO_2 outgassing back to the atmosphere.

Another essential aspect of marine climate regulation is the issue of impermanence. It is usually customary to regard carbon as permanently sequestered if its removal period from the atmosphere exceeds 100 years (Murray and Kasibhatla, 2013). However, the amount of carbon which remains within the ocean for shorter periods in effect contributes to the temporary reduction of greenhouse gasses and delays climate change phenomena. Thus, for each given period, the flux of carbon into the ocean can be partitioned into a permanent and impermanent compartments.

This study asserts that in order to properly assess climate regulation, the temporal fate of absorbed CO_2 must be taken into account. In other words, the benefits of climate regulation stem from the duration of lowered concentrations of atmospheric CO_2 due to its deposition in the ocean and that this duration should be assessed against human context. Without accounting for the entire processes involved in the biological pump or their duration, an erroneous calculation of this ecosystem service, both physically and economically, might occur.

Despite the fact that no regular market exists for the climate regulation ecosystem service, its economic benefits can be estimated using indirect valuation techniques. A favored method is the market price of carbon, as established by emission trading schemes. The European Union Emissions Trading Scheme (EU-ETS) represents the largest cap and trade scheme in the world, in which individual emitters are given a certain emissions allowance (cap) and are able to trade with other emitters in order to meet their emissions allowances or to assist others to meet theirs. Trade within this scheme yields a market price for carbon, which can serve as a value for the climate regulation ecosystem service. However, it should be noted that as a valuation tool, this approach has proved to be inconsistent due to the erratic behavior of carbon markets caused by improper permits' allotment, global economic market behavior and uncertainty over future climate change effects (Tietenberg, 2013).

One of the most accepted valuation approaches is the Social Cost of Carbon (SCC), which represents the marginal damages associated with additional increase of greenhouse gasses in the atmosphere. It can also be defined as a level of Pigovian tax that should be applied to CO_2 emissions (Tol, 2008). SCC is often computed using Integrated Assessment Models (IAM), which take into account various socio-economic and climate-related geophysical parameters in order to assess climate change related policies. Among the factors controlling the resulting values of SCC are risk aversion, social discount rate and accompanied uncertainty. These factors are fed into the IAMs' analyses, each employing different methodology, coupled with various assumptions regarding expected changes in production, consumption and welfare. The numerous options associated with these assumptions and parameters result in a wide range of SCC values (van den Bergh and Botzen, 2015). One of the most prominent SCC estimations was performed by the Interagency Working Group on Social Cost of Greenhouse Gases (2016), taking into account the different IAMs and yielding a range of SCC values, depending on the chosen discount rate. Given the fact that SCC valuations are often subjected to general preferences and that no such estimation exist for Israeli context, any such valuation will provide only an approximation of the SCC value suitable for the case study in question. Nonetheless, compared with carbon valuation methods relying on emission trading schemes, SCC exhibits reduced margin of error under uncertain conditions and is more cost effective (Tol, 2017).Unlike other valuation methods, SCC deals directly with climate change damages and it can be argued that the values obtained using this methodology represent more accurately the benefits of the climate regulation ecosystem service.

2. Materials and methods

2.1. Model outline

The assessment of the climate regulation ecosystem service, indicated by organic carbon fluxes to deep oceanic layers and their concomitant economic values, was carried out for the Israeli Exclusive Economic Zone (EEZ) (ca. 27,700 km^2). The valuation extended between the years 1998–2015 in order to derive monthly and

annual averaged values and to identify inter-annual trends. In addition, the annual average carbon sequestration was used to project future levels of the ecosystem service until 2050, given future SCC values and physical changes of carbon sequestration.

The focus of the assessment relied on underlying ecosystem functions that take place in surface waters over short periods of time. Therefore, a simplified vertical model of the water column was used, obviating the need of taking into account spatial processes such as lateral flow of organic carbon below the euphotic layer, which results in a spatial distribution of organic carbon which differs from that of surface waters.

The methodology for evaluating the ecosystem service is detailed in Fig. 1. First, primary productivity for the years 1998–2015 was obtained for the Israeli Mediterranean Sea in order to establish long-term average and observe any inter-annual trends (step 1). Next, the flux of organic carbon exported from the euphotic zone was computed (step 2). The spatial analysis was carried out only for depths greater than 100 m in order to exclude coastal areas where vertical mixing may counter long durations of carbon sequestration. The flux was then partitioned into permanent sequestration (the amount of carbon that remains in oceanic layers over 100 years) and impermanent sequestration (the amount of carbon subjected to remineralization and leakage back to the atmosphere over a period below 100 years), as shown in step 3. The annualized average of the permanent and impermanent carbon flux served as a baseline for the valuation, using SCC values, of the ecosystem service under current conditions and projected values until 2050 (step 3). In comparison, previous assessments of marine climate regulation only considered steps 1 and 4, omitting the fate and residence time of organic carbon once it was produced. All computations and processing were performed on 3.5 km^2 grid cells using ArcMap 10.3.1.

2.2. Primary productivity and carbon export

The supply metrics of the climate regulation ecosystem service (i.e. tons of carbon sequestered) are based primarily on primary production, i.e. fixation of atmospheric CO_2 by photosynthesis of marine micro-algae, which takes place in the euphotic zone. The Vertically Generalized Production Model (VGPM), a primary production algorithm (Behrenfeld and Falkowski, 1997) was chosen due to its compatibility with local primary productivity estimates. Data layers for this parameter were taken from Ocean Productivity website (www.science.oregonstate.edu/ocean.productivity/index.php). After its formation, there is an organic carbon flux from surface waters to depths below the euphotic layer. The quantity of exported organic carbon was determined by the ratio of exported organic carbon to total primary productivity, denoted ef-ratio (Laws et al., 2000). The ef-ratio (*EF*) for the Israeli EEZ is dependent both on the seawater temperature and primary productivity rates and was calculated using Eq. (1) (Laws et al., 2011).

$$EF = 0.04756 \cdot \left(0.78 - \frac{0.43 \cdot SST}{30}\right) \cdot PP^{0.307} \quad (1)$$

where *SST* is the sea surface temperature in °C, interpolated from *in situ* and remotely sensed data by Copernicus Marine Environment Monitoring Service (http://marine.copernicus.eu/) and *PP* is the primary productivity rates (based on VGPM model data) in tons carbon/month. The exported fraction of organic carbon (in tons), denoted *E*, was calculated on a monthly time scale (l) between the years 1998–2015, for each coordinate in the context area (x, y) according to Eq. (2). The annual average for this time period (216 months) was then calculated (Eq. (3)) in order to establish the exported carbon baseline (E_0).

$$E_l = \int_l PP(x,y) \cdot EF(x,y)dl \quad (2)$$

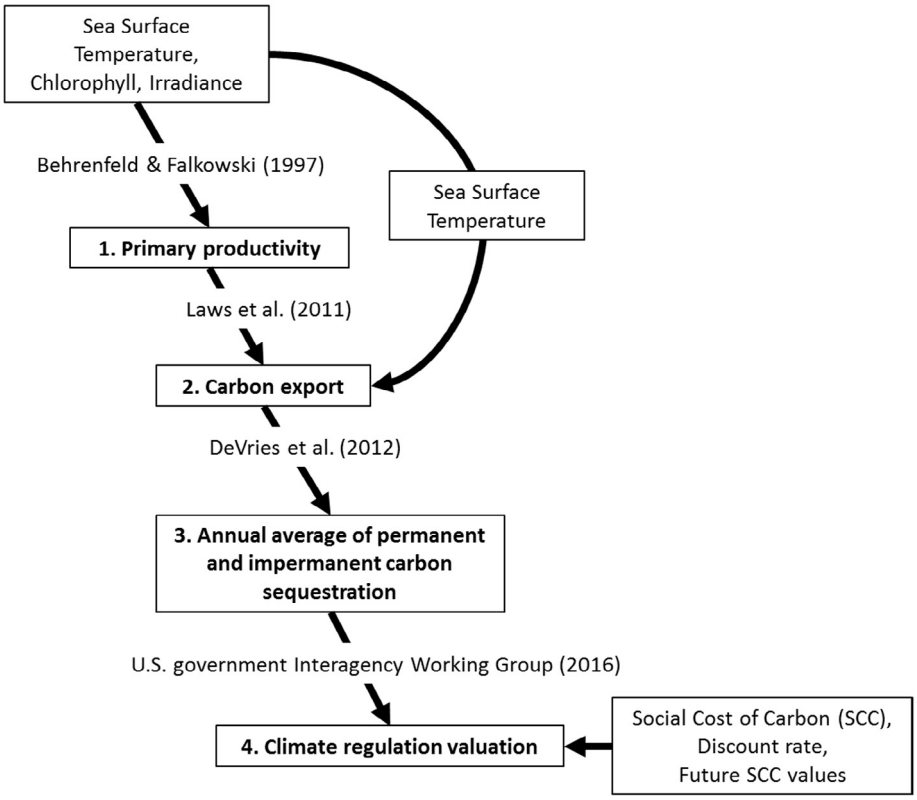
Sea Surface Temperature, Chlorophyll, Irradiance
Behrenfeld & Falkowski (1997)
Sea Surface Temperature
1. Primary productivity
Laws et al. (2011)
2. Carbon export
DeVries et al. (2012)
3. Annual average of permanent and impermanent carbon sequestration
U.S. government Interagency Working Group (2016)
Social Cost of Carbon (SCC), Discount rate, Future SCC values
4. Climate regulation valuation

Fig. 1. Outline of the methodological steps used to assess the climate regulation ecosystem service.

$$E_0 = \frac{\sum_{l=1}^{216} E_l}{18} \quad (3)$$

The Eastern Mediterranean Sea is experiencing rapid environmental changes which are predicted to have profound implications on the future state of its ecosystem. These changes, such as sea temperature and salinity increases, are expected to affect primary productivity through the creation of a shallower mixed layer, thus limiting nutrient supply to the surface (Berman-Frank and Rahav, 2012; Stambler, 2014). In addition, the levels of nutrient fluxes into the basin originating from multiple sources, essential to primary productivity, have also changed over the years (Krom et al., 2014; Suari and Brenner, 2015). In light of the complexity of the ecosystem's biogeochemical dynamics and limited data, prediction of the future levels of climate regulation remains unclear. Historic measurements spanning 30 years have shown consistent long-term increase in both temperature and salinity (Ozer et al., 2016). Following the aforementioned observed linear trends of variables responsible for dictating the levels of climate regulation, we assume that future climate regulation will exhibit the same linearity.

Therefore, the expected carbon flux in subsequent years (E_t) was established using a linear regression analysis of the monthly exported carbon flux, which revealed a decreasing trend, corresponding to an annual loss of 97 tons of carbon (denoted by L in Eq. (4)).

$$E_t = E_0 - (t \cdot L) \quad (4)$$

2.3. Permanent and impermanent carbon sequestration

Permanent carbon sequestration can be defined as the removal of carbon from the atmosphere for a period over 100 years (Murray and Kasibhatla, 2013). This is achieved in the marine environment via the sinking, deposition and burial of organic carbon over this time period by the biological pump. However, a large fraction of the total exported organic carbon is reemitted back to the atmosphere during the 100-year period through remineralization and respiration of the organic carbon. DeVries et al. (2012) define the biological pump's sequestration efficiency as "...the proportion of nutrients regenerated from organic matter exported out of the euphotic zone... that remain sequestered below the surface..."(page 1) for a specified period or longer. Following this proposition, they demonstrated for different seas and time periods the proportion of exported carbon that remains sequestered. Based on the findings of the model presented in DeVries et al. (2012), Eq. (5) shows, specifically for the Mediterranean Sea, the proportion of exported carbon stock, D, that remains sequestered beneath the euphotic zone for each year n ($n = 1 \ldots 99$), after its initial formation and exportation. The reemission rate of organic carbon back to the atmosphere follows an exponential decay form, when during the initial years after its formation, most of the exported carbon is reemitted.

$$D_n = -0.135 \cdot \ln n + 0.94 \quad (5)$$

Eq. (6) presents, for each year, t, the amount of sequestered carbon in tons (denoted as S), of both the permanent and impermanent fraction. M represents the fraction of exported carbon that remains beneath the euphotic zone for a period of over 100 years and is set at 0.3 for the Mediterranean Sea (DeVries et al., 2012).

$$S_t = E_t \cdot M + \sum_{n=1}^{n=99} [E_t \cdot (1 - M) \cdot (D_n - D_{n+1})] \quad (6)$$

2.4. Monetary valuation of the climate regulation ecosystem service

In order to assess the present climate regulation value, SCC values provided by the Interagency Working Group on Social Cost of Greenhouse Gases (2016) were used. These are based on the incorporation of the three most used IAMs (PAGE, FUND and DICE), thus representing an adequate valuation that takes into account the possible differences between them. Three SCC values and their future trajectories were chosen, differentiated by their discount rate (5.0%, 3.0% and 2.5%). This results in a range of possible climate regulation values, providing a wide basis for possible policy making related to this ecosystem service. Under this valuation, SCC values increase over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change.

The SCC value of each year t was calculated using Eq. (7), where r is the annual growth rate of the SCC value, which is determined by the discount rate i and the corresponding decade. SCC values and annual growth rates (Table 1) were taken from the Interagency Working Group on Social Cost of Greenhouse Gases (2016). Baseline SCC values for the year 2016 ($t = 0$) were set at 34.22€, 121.33€ and 183.55€ per ton of carbon, corresponding to 5.0%, 3.0% and 2.5% discount rates, respectively.

$$SCC_{i,t} = SCC_{i,t-1} \cdot (1 + r_{i,t}) \quad (7)$$

Based on Eqs. (6), (8) represents the valuation of the permanent and impermanent organic carbon stocks for each year and selected discount rate ($V_{i,t}$), starting with the year 2016 ($t = 0$).

$$V_{i,t} = E_t \cdot M \cdot SCC_{i,t} + \sum_{n=1}^{n=99} \{E_t \cdot (1 - M) \cdot (D_n - D_{n+1}) \cdot [SCC_{i,t} - SCC_{i,t} \cdot (1 + r_{i,t+n})^{-n}]\} \quad (8)$$

Fig. 2 is given as an example of the total value of the impermanent organic carbon fraction for the year 2017. For each year after the 2017 flux (starting in 2018 until 2116), the impermanent carbon fraction decreases because of the gradual outgassing of carbon back into the atmosphere (dotted line). The value of the impermanent carbon flux exhibits the tradeoff between low SCC values associated with high short-term carbon quantities at the beginning of the period and higher SCC values of longer-term carbon stocks at the end of the 100-years period (solid line).

3. Results

The results of the climate regulation model, presented in figure Fig. 3, demonstrate a clear seasonal trend, with high carbon flux values during the winter and spring and low values during summer and autumn. An inter-annual decline in the supply of climate regulation was detected for the observed time period and was calculated at a loss of 97 tons of carbon per year. The average annual organic carbon flux out of the euphotic layer in the observed area was estimated at ~427,228 tons of carbon. This amount corresponds to an average of 17.49 g C m^{-2} $year^{-1}$, similar to observed carbon fluxes in the Eastern Mediterranean, e.g. Gogou et al. (2014), which reported a flux of 15.67 g C m^{-2} $year^{-1}$.

Fig. 4 shows the spatial distribution of average annual carbon sequestration for the years 1998–2015. As expected, the levels of this ecosystem service are high near the continental shelf, due to

Table 1
Annual SCC growth rate according to the Interagency Working Group on Social Cost of Greenhouse Gases (2016).

Years	5% ($i = 1$)	3% ($i = 2$)	2.5% ($i = 3$)
2010–2020	1.2%	3.2%	2.4%
2020–2030	3.4%	2.1%	1.7%
2030–2040	3.0%	1.9%	1.5%
2040–2050	2.6%	1.6%	1.3%

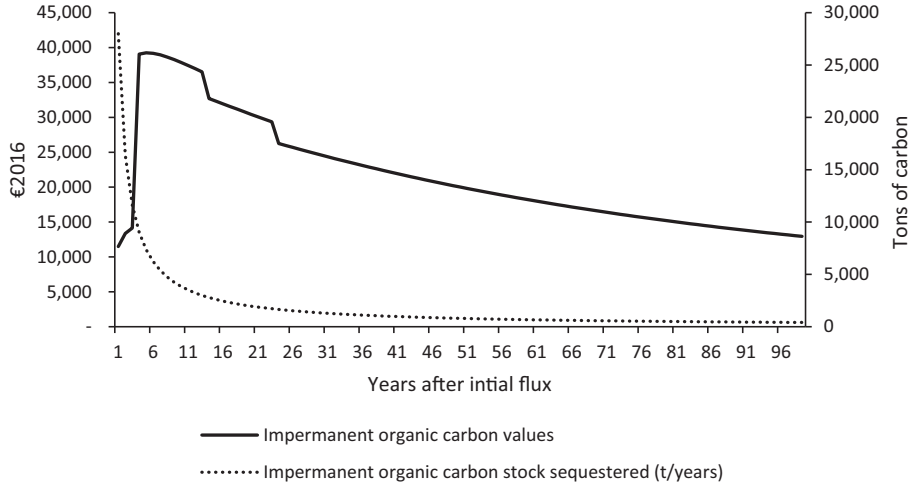

Fig. 2. Impermanent carbon sequestration levels and values for exported organic carbon for the entire Israeli EEZ in the year 2017.

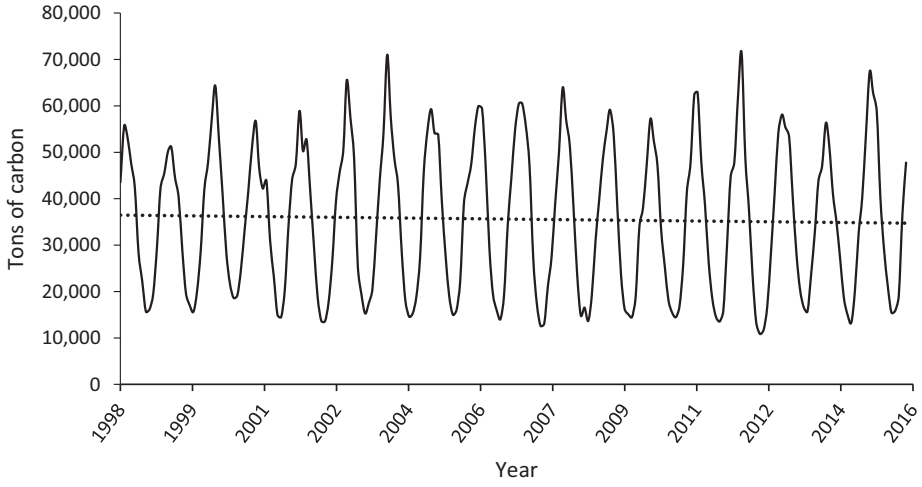

Fig. 3. Monthly organic carbon flux from the euphotic layer of the Israeli EEZ (in tons of carbon), for depths below 100 meters, between January 1998 and December 2015. Dotted line represents inter-annual decreasing trend of carbon flux.

higher nutrients availability (some from anthropogenic sources) and phytoplankton concentrations. The results of the economic valuation are presented in Table 2.

Projected climate regulation values are displayed in Fig. 5. Although a projected annual loss of 97 tons of sequestered carbon for the entire EEZ, rising SCC values render this ecosystem service more valuable in the future.

4. Discussion

This study estimated the physical levels of the climate regulation ecosystem service and its economic value for the Israeli EEZ by spatially modeling organic carbon sequestration below the euphotic layer. The results hint to a relatively limited supply of this service, mainly due to the oligotrophic nature of the eastern basin of the Mediterranean (Kress et al., 2014; Rahav et al., 2013). This valuation is lower than that of Mangos et al. (2010), which estimated the annual value of this ecosystem service for Israel at €72 million (based on emissions trading schemes with an average price of €20.5 per ton of carbon, at 2005 prices). This is mainly due to the fact that their valuation was largely based on the solubility of atmospheric CO_2. However, our results are higher than a recent study by Melaku Canu et al. (2015), which estimated this ecosystem service at €2.7 million (using SCC of €19/t CO_2), translated to 38,720 tons of sequestered carbon, most probably because the exclusion of impermanent carbon sequestration. When comparing this analysis with previous estimations of the climate regulation ecosystem service (Section 1.1), a clear difference arises. Indeed, primary productivity removes CO_2 from the atmosphere, but in the temporal context of societal benefits, much of the carbon is rapidly released back into the atmosphere. We argue that in the case of climate regulation, the cumulative ecological processes involved in generating the social benefit (removal of atmospheric CO_2 for extended periods of time) must be considered while taking into account both permanent and impermanent fractions of sequestered carbon. Assessing climate regulation solely based on the initial process involved (i.e., primary productivity), eventually leads to erroneous and possibly overestimated valuations, as seen in past valuations. When comparing between different valuations of climate regulation, it is important to recognize that while the choice of the monetary valuation vehicle may be a subject for discussion and alternating values, the physical basis of the assessments should reflect the actual nature of the mechanism providing this ecosystem service. A comparison of valuations would also render it ineffective given the heterogeneity of primary

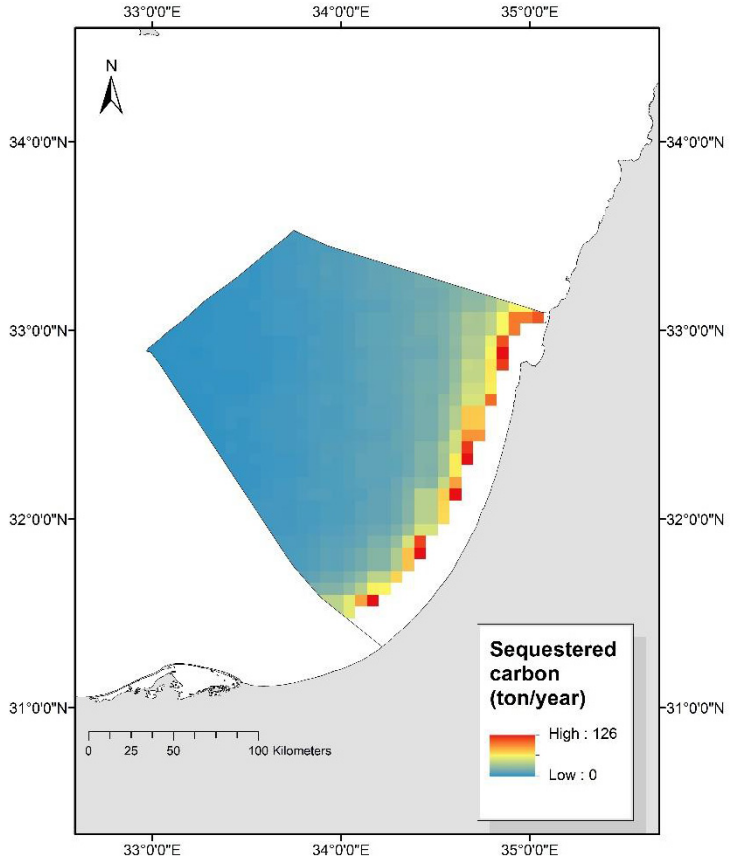

Fig. 4. Spatial distribution of sequestered carbon (1998–2015). Each pixel with an area of ~3.5 km^2.

Table 2
Annual average economic values of the climate regulation ecosystem service for the Israeli EEZ (1998–2015).

Discount rate	Value (€/ton C)	Climate regulation value (Mill. €)
5.0%	34	6.48
3.0%	121	21.39
2.5%	184	31.05

productivity in different areas. Thus, the comparison should be based on the application of the methodology used to derive the physical metric of the valuation. Using the methodology of past estimations, the average value of primary production in the Israeli EEZ is 124.9 ton C km^{-2} year^{-1}, 7 times higher compared with 17.49 ton C km^{-2} year^{-1} in this study.

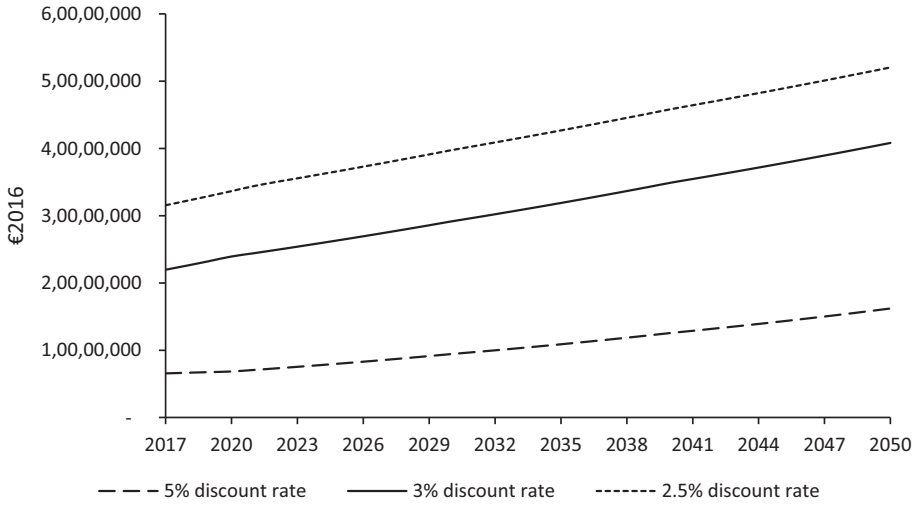

Fig. 5. Projected climate regulation values until 2050 using different social discount rates.

Given these results, some remarks are in order:

1. Indeed, the Israeli EEZ acts as a source of atmospheric CO_2 when accounting for the solubility pump (i.e. transport of atmospheric CO_2 to the sea through air-sea exchange) but its biological sequestration component, although limited by the oligotrophic nature of the ecosystem, has a valuable contribution to mitigating climate change implications.
2. The economic value of this ecosystem service is dependent on the chosen SCC value, discount rate and the physical model used to estimate primary productivity, and therefore exhibits a wide range of values accordingly. Although the former is subject to further enhancement and validation, social and economic preferences, determined by policy makers, have a considerable effect on resulting ecosystem values. In the context of the Israeli Mediterranean, the Israeli Ministry of Environmental Protection recommends using a 3.0% discount rate, yielding an annual value of €21.39 million for climate protection.
3. The marine ecosystem is comprised of multiple components featuring intricate bonds and mechanisms. Assessing the economic implications of management policies or external environmental pressures in the form of marginal values becomes much more complex under uncertain conditions and lack of data. Without clear knowledge on the mechanisms of the Israeli Mediterranean ecosystem, attempting to force marginal changes in order to derive economic insights might lead to unsubstantiated results. Future data on the inner workings of this marine ecosystem will help better evaluate hypothetical scenarios and their implications for ecosystem services' values.
4. The partition of exported carbon between permanent and impermanent as well as the rate of outgassing of the impermanent fraction of organic carbon back to the atmosphere are based on a general model, presented by DeVries et al. (2012). Future *in situ* data acquisition for Levantine waters will undoubtedly contribute to honing the valuation results.
5. The trends that were calculated based on observed data are linear in nature. However, the response of the biological functions and organisms involved in the future supply of the climate regulation ecosystem service, under varying conditions, will not likely follow the same path, as a new equilibrium will be established over time. The future levels of the climate regulation will inevitably be associated with the biological components of the ecosystem, such as phytoplankton functional types, which are highly dependable on environmental variables such as sea temperature or alkalinity of the Mediterranean (Stambler, 2014). The uncertain trajectory of the ecosystem's response to the changing environment warrants further investigation of possible ecosystem phase shifts and their expected outcomes.

This study examines the historic and expected supply of climate regulation. Valuation of the demand for this ecosystem service, however, is more difficult due to its nature as a public good whose benefits are manifested on an international level. Due to rapid atmospheric mixing and the encompassing nature of climate change effects on human welfare, it is hard to attribute local or national sources of climate regulation to any specific beneficiaries. Thus, a spatial discrepancy exists between the ecological scale of supply and the institutional scale of demand (Arriagada and Perrings, 2011). In the case of the Israeli EEZ, the marine ecosystem supplies transboundary climate regulation benefiting all global stakeholders. We propose to address the supply and demand scale disparity using two policy-related measures: national environmental accounting and Ecosystem-Based Management. The first measure is the incorporation of the climate regulation ecosystem service into national accounting as a natural capital asset (United Nations, 2014). Conventional systems of national accounting make use of Gross Domestic Products (GDP) as key indicator for wellbeing while environmental national accounting seeks to integrate sustainability indicators of natural assets and flows into such accounts for wellbeing measurement. By incorporating the physical and economic values of climate regulation into environmentally-modified national accounts (e.g. via the System of Environmental-Economic Accounting; United Nations et al., 2014), a shift at the institutional scale from global interest to national interest can be obtained (Hein et al., 2006). By accenting the importance of climate regulation on the national scale (e.g. its importance in achieving national Sustainable Development Goals; Almassy, 2014), an increase of demand for its continued supply is expected. The second measure emanates from the increased national demand for climate regulation following its incorporation into national accounting. The level of primary productivity is partially determined by parameters such as nutrient supply and grazing pressure by various herbivores, which can be managed to a certain degree by human intervention. In the case of nutrient supply, the level of nutrients from coastal and estuarine sources is highly dependent on regulatory actions carried out at the national level. On the other hand, herbivore grazing of phytoplankton can be regulated to a certain degree by top down control following changes in the food chain composition (e.g. regulations altering fishing effort; Spiers et al., 2016). The specific regulatory pathways under such national accounting procedures and Ecosystem Based Management schemes is beyond the scope of this study but their implementation warrants future research efforts focusing on uncertainty reduction, especially in the context of high-seas, where data scarcity is prevalent. Correct and accurate understanding of the magnitudes and trends of different ecosystem services is crucial for the application of Ecosystem Based Management (EBM) policies. Therefore, the need to review the different components and processes involved in the creation of ecosystem services' values must be stressed in order to avoid inaccurate future valuations. Although performed at a local level, the insights from this study apply to other magnitudes and ecosystem services.

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